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Desert Rodent Abundance in Southern Arizona in Relation to Rainfall

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Desert rodent populations in southern Arizona fluctuated in rodent numbers and rodent species composition over a 30-year period. Data indicate that the direction of these annual fluctuations can be predicted from the amount of rainfall received during the previous year.

Keywords: Rodents, rainfall, desert.

Though information is available on rodent population fluctuations in more moderate climates, little is known about such populations in deserts, especially for an extended period. These animals often are exposed to habitat conditions related to low precipitation. Knowledge of how desert rodent species react to environmental conditions will contribute to a better understanding of small mammal population fluctuations.

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In this study, rodent population density variations in desert grassland vegetation of southern Arizona were determined by a trapping census conducted during a 30-year period. Rodent abundance data is related indirectly to habitat conditions that respond to annual precipitation. Data were obtained from continuation of a project initiated by Reynolds (1958) on *Dipodomys merriami*. We are grateful to the late Hudson G. Reynolds who initiated the study and supervised data collection.

The study was conducted in mesquite-grassland along the Santa Rita Mountains on the Santa Rita Experimental Range about 56 km southeast of Tucson, Pima County, Ariz. The Range extends from an elevation of 884 m at its northern boundary to 1,311 m along the foothills of the Santa Rita Mountains. Annual rainfall on

the study site at the lower elevation averages 25.4 cm. There has been controlled cattle grazing on the area since 1915. The topography is flat, and soil varies from fine to coarse sandy loam.

The southwestern desert grassland climate generally is characterized by high rainfall and temperatures in summer, low rainfall and intermediate temperatures during spring, and low temperatures and intermediate rainfull during winter (Table 1). Average monthly precipitation varies from a low of 0.5 cm in May to a high of 10.7 cm in August. Mean monthly temperatures reach a low of 8°C in January and rise to a high of about 29°C in July. If rainfall is favorable, temperatures permit growth of some plants during winter. Additional plant growth begins after favorable summer rains.

Table 1.—Mean rainfall values (cm) at the Santa Rita Experimental Range study site, Arizona, 1942-1972.

Season	Rainfall category		
	Lowest years	Medium years	Highest years
Spring Feb.–May	4.0	6.3	4.0
Summer June–Sept.	10.0	19.0	27.5
Winter Oct.–Jan.	4.8	7.6	10.4
Total	18.4	33.0	41.9

Four snap-trap lines were set in December for 22 years during the period from 1942 through 1972 at each of three sites about 1.6 km apart. A trap line consisted of 10 museum special traps spaced 14 m apart and set for three successive nights. Three rat traps added to each line indicated the presence of larger rodents. The bait was rolled barley. Data from snap-trap lines were expressed as numbers of animals per species captured during the total of 468 trap nights a year.

Results and Discussion

Ten rodent species were trapped on the study area: Merriam and bannertail kangaroo rats, (*Dipodomys merriami* and *D. spectabilis*); Bailey (*Perognathus baileyi*) and desert pocket mice (*P. penicillatus*); grasshopper mouse (*Onychomys leucogaster*); cactus mouse (*Peromyscus eremicus*) and deer mouse (*P. maniculatus*); white-throated wood rat (*Neotoma albigula*); and two ground squirrels—the round-tailed ground squirrel (*Spermophilus tereticaudus*) and Yuma antelope squirrel (*Ammospermophilus harrisi*).

A total of 2,201 animals from 10,296 trap nights were taken during 22 sample years. The total rodent catch varied from 176 in 1959 to a low of 9 (all *D. merriami*) taken in 1943. *D. merriami* made up 73% of the total number of rodents trapped during the entire study period. Other significantly abundant species were *O. leucogaster*, which contributed more than 10%, *P. baileyi* (6%) and *P. penicillatus* (5%). All other species combined accounted for 6% of the total catch.

In the following discussion, numbers of animals trapped in December are considered to be representative of annual species populations. The annual combined total of all species populations fluctuated during the 22 years of data collection. The populations of individual species also varied greatly during successive years. For example, only 12 *D. merriami* were taken in 1954, while 135 were caught the next year; *O. leucogaster* increased from 1 to 7 from 1953 to 1954, and *P. penicillatus* increased from 3 to 27 from 1950 to 1951. Those species with lower population levels such as *D. spectabilis*, *P. eremicus*, *N. albigula* and *A. harrisi*, seemed to be more stable from one year to the next. Each rodent species reached population peaks and lows in different years.

Annual changes in species composition and total rodent numbers are difficult to explain since deaths, emigrations, immigrations, food abundance, floods, and droughts influenced the populations (Reynolds 1958). In desert habitats, however, rainfall could be one of the most important factors directly or indirectly influencing desert rodents.

All tests comparing total rodents and individual species numbers with the total rainfall for the same year were insignificant. However, the correlation for total annual rodent numbers approached significance with the amount of rainfall the previous year ($r^2 = 0.59$ and $P = 0.05$). The total average rainfall of years that preceded the top five rodent production years was 10.2 cm greater than the rainfall mean of years preceding the lowest five years. A similar significant difference of 8.8 cm was recorded when rainfall associated with the 11 peak years of rodent production was compared with the 11 lowest years.

Grouping annual rainfall totals into three broad categories showed a significant relationship between rodent numbers and rainfall (Table 2). In this analysis, annual rainfall categories were: low, 17.8-27.9 cm (7 years); medium, 27.9-38.1 cm (10 years); high, greater than 38.1 cm (5 years). Annual total rodent population was greatest when the previous year's rainfall was in the highest category. The total rodent populations of the years following lowest rainfall was about half that following the high rainfall years.

Annual population peaks of the different species did not coincide, suggesting that each one

Table 2.—Individual species abundance means on the Santa Rita Experimental Range in relation to rainfall categories.

Species	Rainfall category: Lowest years	Medium years	Highest years
Merriam kangaroo rat	40.3[b][1]	84.4[a]	93.2[a]
Bannertail kangaroo rat	1.1	0.2	0.4
Bailey pocket mouse	4.6 ± 1.2	8.3 ± 1.6	4.4 ± 1.6
Desert pocket mouse	5.4 ± 2.5	5.0 ± 2.5	3.6 ± 1.0
Grasshopper mouse	4.7[b]	14.4[a]	10.4[a,b]
Deer mouse	0.0	1.0	3.6
Cactus mouse	0.6	2.0	1.8
White-throated woodrat	2.1	1.6	0.4
Harris antelope squirrel	0.9	0.7	0.4
Roundtail ground squirrel	0.1	0.0	0.0
Total rodent population	59.9[a,b]	117.6[a]	119.2[a]
Previous year's rainfall (cm)	17.8-27.9	27.9-38.1	38.1-50.8

[1]*Values within a column with unlike superscript letters are statistically different (P < .05).*

reacted differently to environmental factors. Total *D. merriami* numbers increased from an average population size of 40.3 during years in the low rainfall category to 84.4 during average years, and 93.2 in years following heavy rainfall. However, *D. spectabilis* and *N. albigula* were at their highest densities when preceding years' rainfall was least. Species that were most abundant when associated rainfall was greatest were *D. merriami, P. manicultatus* and *A. harrisi.*

P. maniculatus usually had low populations during years when other rodents were at population peaks. For example, the three greatest years for the total of the other rodents were 1945, 1955, and 1959. During these years, only one *P. maniculatus* was taken. Although populations of this species were enhanced during the years with the greatest amounts of rainfall, they did not reach levels near one per trap night as reported by Hoffman (1955) in Mono County, Calif.

There seemed to be reverse trends in populations numbers between *D. spectablis* and *N. albigula. D. spectabilis* was represented during only 4 of the 12 years that *N. albigula* was taken.

Reynolds (1958) reported little competition between rodents on the Santa Rita because of feeding behavior and preferences. Comparisons of population levels of the seed-eating rodents (*Dipodomys* spp. and *Perognathus* spp.) indicated that, in 1955, when *D. merriami* was at its greatest density, other seed-consuming species such as *D. spectabilis* and *P. baileyi* were not taken, and *P. penicillatus* was at a low level. Likewise, the greatest populations of these latter three species were attained during years when *D. merriami* was at low densities. The low population years of the three rodents might be due to reasons other than food competition with *D. merriami,* since the four species differ in feeding behavior and preferences (Vorhies and Taylor 1922, and Reynolds 1958).

Precise seasonal habitat information was not obtained throughout the 30-year study period. However, Reynolds (1958) reported on seasonal environmental influences on the Santa Rita rodents during the period from 1943-1952. He found that kangaroo rat numbers were greatest in July when immature animals were most abundant. Examination of the December trapping survey data revealed no correlations between percentages of immature individuals in the annual rodent population and rainfall of the same year or previous years. There were also no significant differences when percentages of immature individuals in the entire rodent population during years with less than 5.0 cm of October through January rainfall were compared with years in which rainfall was greater than 5.0 cm.

Because most of the rodents on the study area had the potential to produce several litters annually, it appears that their populations should increase during a year of heavy precipitation, especially if the rainfall precedes the summer breeding season. However, heavy downpours seem to depress populations due to flooding of the rodent burrows (Fitch 1948, Grinnel 1939, Reynolds 1958).

The amount of rainfall during the previous year seemed to influence the population numbers of most of the rodent species. Smith et al. (1974) also considered the previous years' rainfall as the most important weather variable in a small mammal population in a hardwood forest in South Carolina. Seed-eaters and species more indirectly associated with grasses or forbs such as *O. leucogaster* and *Peromyscus* spp. increase when rainfall enhances plant growth. When these species are at low population levels, competitors or marginal species apparently are favored. *D. spectabilis* and *N. albigula* populations appear to be more independent of rainfall.

Relating rainfall classes to species population levels indicates that most of the other desert rodents benefit when rainfall during the previous year is 27.9 cm or more. However, precipitation above 38.1 cm does not increase proportionately the total annual production of rodents. Perhaps intrinsic factors such as territorial competition are more important at high population densities, or environmental factors, such as increased cover for predators, tend to suppress the high populations. Though there are a wide variety of factors influencing desert rodent numbers, it appears that the direction of annual population fluctuations can be predicted from the amount of rainfall during the previous year.

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